The Liburdi Group of Companies
providing specialized Technologies, Systems, and Services for Turbine, Aerospace and Industrial Applications.

Since 1979, Liburdi has pioneered in the development of metallurgical processes and technologies required for reliable analysis and refurbishment of aero and industrial gas turbine components. Through innovation and dedication to quality, Liburdi has become a recognized leader in turbine repair and life extension technologies, as well as a supplier of automated equipment used to weld, machine and coat aerospace and industrial components. Liburdi provides a comprehensive range of products and support services including:

Materials Engineering Services
- Manufacture and Repair Support
- Failure Analysis
- Remaining Life Analysis
- Metallurgical Laboratory Analysis
- Materials Seminars
- Welding Process Development

Gas Turbine Services
- Component Refurbishment
- Rejuvenation Heat Treatments
- Efficiency and Power Upgrades
- Component Redesign and Modification
- WinGTAP™ and LGTP-Health™ Diagnostic and Performance Software
- Turbine Fleet Management

Metallurgical Processes
- LPM™ Powder Metallurgy Process
- GTAW, PAW and Laser Welding Processes
- LFX™ Welding Fluxes
- LOM™ and LSFR™ Coating Processes
- CVD & PVD Coating Systems
- Overlay Coating Processes
- Plasma Spray Processes
- Chemical Stripping Processes
- Vacuum Heat Treatments
- Hot Isostatic Pressing
- Laser Processing

Precision Welding Equipment
- LAWS™ Automated Welding Systems
- Laser, Plasma, GTAW Automated Welding
- Dabber® Welding Systems
- LVS® Machine Vision
- LST® Laser Seam Tracking
- LRC® PC Based Controllers
- Automated Machining Systems
- Orbital Tube and Pipe Welding Systems
- Pulsweld®, Dimetrics®, Hobart® Power Sources
- Merrick® Engineering Systems
- Machine PAW torches
- Weldline® Seamers
- Precision Welding Lathes and wire feed units
- Custom Industrial Welding Systems
- Nuclear Welding Systems

Liburdi Engineering provides a diverse range of turbine services, metallurgical analysis, mechanical design, performance monitoring, repair development and corporate research and development. Our services in the turbine industry complement those offered by the original engine manufacturers while providing the added benefit of an independent engineering analysis and advanced, life extending, refurbishment processes and coatings.

Liburdi Automation is the manufacturer of high precision, vision based LAWS®, Dabber® and Pulsweld® power sources, multi-axis articulated motion systems and controllers for applications in turbine, aerospace, nuclear, industrial and automotive industries.

Liburdi Dimetrics® manufactures an extensive range of orbital welding products and precision lathes, seamers and positioners using advanced technologies acquired from Dimetrics®, Hobart®, Merrick Engineering®, Weldline® and enhanced by Liburdi. These specialized GTAW, PAW and GMAW systems and controllers are used extensively for precision welding of tube and pipe, medical devices, industrial, nuclear power generation and automotive components.
Liburdi Engineering provides comprehensive metallurgical services ranging from analysis of service failures to the development of new technologies, such as advanced welding and joining methods, rejuvenation heat treatments, and protective coating processes. Liburdi’s seminars on turbine materials and welding metallurgy provide unique insight and training for operators and engineers.

**Turbine Component Life Trend Analysis**

Metallurgical examination of hot gas path components assessed for remaining service life includes characterizing the type of damage and quantifying the extent of material degradation so that an informed and cost effective repair or replacement decision can be made.

Components are examined for:
- oxidation/corrosion attack
- coating thickness and integrity
- microstructural degradation
- reduced creep strength
- dimensional changes

Liburdi has developed techniques which have become the recognized industry standard with the issue of “Gas Turbine Blade Life Assessment and Repair Guide” co-authored by Liburdi and published by EPRI. We continue to develop advanced techniques for correlating microstructural and coating changes with service exposure which, along with effective use of Finite Element Technology, enhances the value of the information derived from the components.

**Component Failure Analysis**

The Liburdi team applies an interdisciplinary approach to the analysis of turbine failures. Our staff includes engineers experienced in engine and component design, aero-dynamics and performance analysis, repair and coating technologies, as well as metallurgy and materials expertise. By analyzing a failure or reduced component life from several perspectives, we are able to identify the problem and its cause, and to further advise on how to prevent its re-occurrence.

Our metallurgical engineers and technologists are fully experienced in the materials and high strength superalloys used in today’s gas turbine engines. We have developed a unique understanding of the behavior of these complex alloys and specialize in the analysis of their service behavior.

**Laboratory Facilities**

Liburdi has a fully equipped metallographic laboratory including facilities for mechanical testing and non-destructive chemical analysis. Our affiliation with McMaster University provides the latest in metallurgical analytical equipment, including:
- Scanning Electron Microscopes (SEM)
- Transmission Electron Microscopes (TEM)
- Scanning Transmission Electron Microscopes (STEM)
- Secondary Ion Mass Spectroscopy (SIMS)
- X-ray Diffraction (XRD) etc.

**Repair Process Specifications**

Detailed specifications define repair requirements and ensure that repairs of acceptable quality and endurance are achieved. Liburdi has developed specifications for use by prominent industry organizations such as EPRI and CTTC. Similar specifications are developed for the turbine operator and are also used for the repairs performed by Liburdi.

**Welding and Joining Applications Analysis**

Our team of specialists analyze weld processes and microstructures and provide solutions in support of customers’ applications for aerospace and advanced manufacturing. This unique expertise allows us to quickly understand the metallurgical requirements and modify the parameters for optimum quality and speed. Applications range from superalloy to steel, as well as copper and aluminum alloys for a wide range of critical products.
Our mechanical engineering services are specifically tailored to gas turbines. This allows us to perform a thorough independent analysis of problems and, where required, to modify or redesign components. Our work scope can vary from stress analysis on rotating blades to determine repair limits to a detailed examination of performance and temperature distribution for the complete engine.

This unique capability has been made possible by the experience and talent of our engineers in the field of engine design. To assist in our analysis, we use advanced computer programs from industry proven sources or developed at Liburdi. Our computer analysis capability includes:

- Finite Element Heat Transfer, Stress and Frequency Analysis
- Cooling Flow and Compressible Flow Network Analysis
- Computational Fluid Dynamics
- Rotor Dynamics
- Turbine Mean Line Aerodynamic Analysis
- Design, Off-Design and Transient Performance Analysis

Turbine Engine Performance Software

Over the years, Liburdi has developed advanced, high precision engine performance models for use in developing performance improvements. These programs are similar to those used by the engine designer and enable a detailed, stage-by-stage analysis to be carried out over the full operating range in support of Liburdi’s engine modification and performance upgrade activities. We also work with the engine manufacturers and provide tailored systems for their engineers to use. Detailed models are developed specifically for each engine model in order to provide this high level of accuracy.

WinGTAP LGTP™ Performance Software

The LGTP™ Performance Software is packaged in an easy to use Windows format and is used by engine manufacturers, packagers and facility developers to predict on-site performance for the full range of on-design and off-design operation. The software is configured specifically for each engine model, either industrial frame or aero-derivative, and can include heat recovery cycles for combined cycle and co-generation installations.

LGTP-Health™ Performance Diagnostic Software

The LGTP-Health™ Software is based on the LGTP™ Performance Software with additional capabilities for engine health monitoring and diagnostics. The software is installed in the engine control room for operations monitoring by our customers to identify and determine the source of performance degradation as well as determine the operating cost of the performance degradation.

Turbine Upgrades and Modifications

When redesign is required, we can provide complete drawings and specifications, and manufacture the modifications in our facility. In many cases these improvements have been adopted and used under agreement by the original engine manufacturer.

Our cooling engine modifications have achieved significant improvements in component life extension, unit reliability and efficiency, and enjoy a proven track record over the years. Benefits are gained through the use of modern design methods and the introduction of elements such as high performance gas seals, cooling flow distribution, high strength materials and coatings.

Our turbine upgrades include steam injection and supercharging for power augmentation, conversions for gas expander use, performance improving transition and seal redesign, and augmented disc and blade cooling for extended creep life.
The repair and manufacturing facilities offered by Liburdi are supported by the extensive experience of our mechanical and metallurgical engineering team. Each job is individually reviewed by experienced engineers who are responsible for specifying the design of the repair, establishing safe limits for the extent and type of repair permitted, and for ensuring the integrity of the part. The result is advanced technologies and experienced supervision for all processes to ensure quality and reliability.

Quality Assurance to the Highest Standards
In addition to ISO9000, Liburdi is DOT/FAA approved for aero component repairs and OEM approved by engine manufacturers and their approved overhaul facilities. We have authored repair specifications for operator groups such as EPRI and CTTC. Liburdi repairs components for the engine manufacturer and directly for the engine owner/operator. Liburdi’s advanced processes are approved and used by the OEM for new part manufacture of the latest engine designs.

Component Repair Specialists
- Industrial frame blades and vanes for extended life
- Aero derivative blades and vanes for extended life
- Combustors and transition repairs
- LAWS™ automated systems for advanced high strength welding
- LPM™ powder metallurgy for superior strength repairs
- Fuel nozzle restoration, re-manufacturing, flow check, re-certification
- Advanced CVD, PVD and Plasma Spray coating systems selected specifically for the type of service

Coating Stripping and Re-Coating
Liburdi’s stripping facility employs the latest technology and precise controls for reliable stripping of components – both internal and external coatings. Multiple stripping tanks are used with chemical solutions and procedures designed specifically for each of the coatings in common use – diffusion aluminides, MCrAlY, TBC. Liburdi has developed advanced CVD coating systems for aluminide coating of internal and external surfaces.

Advanced Technologies for Component Life Extension

Automated Welding
By combining our understanding of materials behavior with advanced automated welding repair techniques, we are able to develop new repair processes for component life extension. Automated welding enables the use of high strength and oxidation resistant weld metals not possible with conventional welding.

Rejuvenation Heat Treatments
Since 1979 we have been the leaders in introducing HIP and rejuvenation heat treatments to fully restore properties of high hour blades. Proven processes have been developed for all blade alloys used in the past as well as the latest Directionally Solidified and Single Crystal alloys.

LPM™ Powder Metallurgy Process
This unique patented process is used extensively as an alternative to welding for high strength, distortion-free repairs for both blades and vanes. The process is OEM approved and enables a wide range of alloys to be used for crack repair and surface build-up. The LPM™ repairs have consistently outperformed conventional weld or braze repairs on numerous engine rainbow tests.

CVD and Overlay Coatings
Advanced systems for applying diffusion aluminide coatings to the external and internal airfoil surfaces as well as a wide range of MCrAlY overlay coatings are applied to suit the specific engine service environment.

Component Refurbishment & Life Extension

LAWS-1000™ System welding HPT blade with oxidation resistant weld alloy for longer overhaul life.

Rejuvenated bucket with improved coating after 24,000 hrs of cogeneration service.

Vane repairs with LPM™ used to reinforce fillets and build up wall thickness.
The unique Liburdi Powder Metallurgy, LPM™, is a patented, advanced joining and cladding process for blades, vanes, and other superalloy turbine components. LPM™ offers superior strength and performance compared to conventional weld and diffusion braze repair methods. The LPM™ process uses mechanical means to remove the crack-damaged areas. Inspections ensure that all weakened material has been removed before the LPM™ materials are applied at room temperature using either a moldable putty or a flexible tape composition. The parts are then heat treated in a vacuum furnace to produce a liquid phase sintered, metallurgical bond with the base alloy. The process is very versatile and materials can be formulated from a wide variety of high strength superalloy powders selected for the specific application, e.g., IN738, Rene80, Mar M247, X40. Compositions can also be designed for wear resistance using Chrome Carbide or abrasive tip materials.

**Blade Repairs**
For nickel based blade superalloys such as IN738 and GTD111, matching powder alloys are used for strength approaching the original component. The strength far exceeds that of conventional weld alloys for high reliability and more extensive repairs. For the latest high performance engines, the process is used by the OEMs to apply an engineered blade tip of abrasive oxidation-resistant alloy to high strength (single crystal) airfoil castings and for closing the cavities that are used to support the internal ceramic core during the casting process.

**Vane and Nozzle Segment Repairs**
For cobalt based vanes such as X40 and FSX414 alloys, high strength nickel based LPM™ powder alloy is used for strength exceeding the original component. In this way, the parts are upgraded by strengthening the damaged areas for future extended service life. LPM™ reconstructed vanes will often outperform the original cast part.

- LPM™ is able to repair crack sensitive alloys without the heat affected zone cracks associated with welding
- LPM™ is able to repair structural areas of vane segments without the local distortion which can be associated with welding
- When used to restore worn or eroded airfoil or shroud surfaces, the LPM™ is applied in a flexible tape form to restore the original surface with a controlled thickness of new superalloy material
- LPM™ is used to reconstruct badly damaged vanes and is superior to coupon replacement.

**Advanced Manufacturing**
The LPM™ materials are also used for new component manufacturing. Typical applications include hard facing of Z notches for shrouded blades, abrasive tips for single crystal blades, closure of core cavities and repair of new castings.

**Advanced Coating Technology**
Liburdi Engineering has pioneered in the development of several unique vapor coating processes capable of depositing wear-resistant and oxidation-resistant coatings. In addition to providing these coating services, Liburdi designs and builds CVD and PVD coating systems for installation at customers’ facilities.

**Titanium Nitride Hard Coatings**
The Reactive Ion Coating RIC™ process is a plasma assisted, electron beam vaporization Physical Vapour Deposition (PVD) process used to deposit hard, erosion-resistant Titanium Nitride coatings. The RIC™ is applied to compressor airfoils in jet engines and some industrial turbines to protect against erosion and the resulting losses in engine efficiency and power. The superior erosion resistance of the RIC™ coating is OEM approved for new blade manufacture for Allison T56 engines operating in the harshest military desert environments. The coating, while extremely hard, is very thin and provides a smoother surface finish for improved aerodynamic efficiency over the life of the overhaul cycle. A three times life improvement has been achieved on T64 and T56 engines operating in severe environments.

**Aluminide CVD Coatings**
The Liburdi LOM™ coating process is a Chemical Vapor Deposition (CVD) process which applies a high purity aluminum coating over the exterior and if required internal surfaces of turbine blades. The unique process enables very complex shapes and internal passageways to be successfully coated with tight control over uniformity of coating thickness. The process can be combined with modifying elements such as platinum or Yttrium to produce high performance modified aluminide coatings for specific applications.

**Aluminide and MCrAlY Overlay Coatings**
Liburdi has developed a group of coatings using a unique slurry application technology for turbine blades and vanes. The application process is used to produce modified diffusion aluminides such as Silicon Aluminide as well as MCrAlY coatings without relying on conventional pack or high velocity spray processes.
Liburdi introduced the first LAWS™ robot system designed specifically for turbine blades and vanes in 1990. Since that time the product has evolved into a family of gantry and rectilinear robotic architectures, each with the latest LRC™ Controller and Liburdi Vision System. These systems are now the industry standard and are used in aero manufacturing and overhaul facilities around the world. Liburdi has a unique understanding of the application of this equipment since the LAWS™ systems are operated in its own repair and manufacturing facility and therefore Liburdi can provide “Turn-Key” solutions including tooling and process development for most applications.

**LAWS™ Automated Welding Systems**

The LAWS™ systems provide superior control of the weld process for improved quality and consistency compared to manual welding of crack-sensitive alloys. Power sources ranging from Micro Plasma to Laser can be used, depending on the application.

The LAWS™ systems are used for shrouded blade Z notch hard facing, unshrouded HPT blade tip repair, compressor blade tip and leading edge restoration, and for manufacturing a variety of cases and circumferential air seals.

Liburdi's Automated Laser System can be configured for a variety of aerospace and industrial applications, such as HPT blades, shrouded LPT blades, compressor blades and seals. The unit is capable of achieving near-net-shape weld geometry and can be supplied with wire or powder delivery systems.

**Systems Integration for Advanced Manufacturing**

The Liburdi team directs its extensive experience to design fully integrated systems to meet the specific requirements of the most challenging manufacturing applications. Single source responsibility for all robotics, integration, power sources, vision, software, tooling, weld development, NDT and metallurgical qualification of weld samples. This same expertise is dedicated to ongoing support for customers and their manufacturing operations. Our applications range from large aerospace systems for VPPA welding of launch vehicles to micro plasma welding of automotive devices.

**Precision Torches and Accessories**

The custom line of GTAW and PAW torches from Liburdi are recognized as the best precision machine and manual torches in the industry. The micro plasma torches are engineered for repeatability and reliability and are the ideal solution for exacting welding applications.

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**Liburdi Vision System LVS™**

The Liburdi Vision System captures a 3-Dimensional image to precisely characterize the motion, shape and thickness of each surface to be welded. The LVS™ directs the torch path and adjusts the weld parameters for consistent welds of the highest metallurgical quality for difficult to weld alloys.

**Pulsedweld® Power Sources**

The Pulsedweld® line of GTAW and PAW power sources offers both high precision and guaranteed repeatability to meet the most demanding applications. The 50/100 amp Micro GTAW/PAW system is designed for low heat input welding, while modular high speed systems ranging from 200 to 1200 amps are available to satisfy larger power requirements. For difficult to weld materials such as aluminum, the patented Pulsedweld® Variable Polarity VP™ technology utilizes its unique cathodic cleaning action to provide enhanced tolerance to surface oxide and contaminants to achieve superior welds.

**Dabber® Automated Welding Systems**

The acquisition of the advanced welding products of Hobart has added the Dabber® automated systems to Liburdi’s product line. An industry standard for over two decades, the Dabber® has now been enhanced with new technology for the most demanding applications of close spaced, thin edge seal restoration.
Liburdi Dimetrics® manufactures an extensive range of automated orbital welding products, precision lathes, and controls for GTAW, PAW and GMAW welding applications ranging from fine, thin wall tube welding to thick wall, high deposition pipe welding.

The Liburdi Dimetrics® and Hobart® line of precision GTAW power sources are designed for tube and pipe welding using automated orbital weld heads and welding lathes. Precise power output is available from models ranging from 150 to 500 amps. The MicroPAW® power source is available as a 20 amp system designed for low heat, precision plasma welding of small components, medical instruments, hermetically sealed vessels, fine wires and bellows.

Gold Track® V Automated Welding System

The Gold Track® V provides an impressive 500 Ampere of power at 100% Duty Cycle. The legendary built in Gold Track® Controller allows synchronized control of 4 to 6 servos and can operate all pipe and tube heads.

Gold Track® V Hot Wire CC™

The Gold Track® V Hot Wire CC™ Automated Welding System produces high quality GTA welds with overall speeds comparable to those of GMAW systems. Its patent pending process automatically adjusts the wire current as the operator increases or decreases the wire feed rate, maximizing deposition rates and reducing overall welding time. The system is available in our standard single hot wire configuration, or in a dual hot wire setup for bi-directional applications.

Model "F" Weld Head

The field-proven Model "F" head is available in MIG, TIG and hot wire configurations. The full function (travel, AVC, wire feed, oscillation) head is renowned for reliability and accuracy. The patented zero backlash traction driven carriage can be easily mounted on various tracks with quick disconnects.

Precision Controls

Liburdi Dimetrics® orbital tube and pipe welding controllers are microprocessor based and available with multi-segment current control, AVC, wire pulsing/oscillation, and real-time data logging capability. For heavy wall applications, the systems feature advanced hot wire and narrow groove technologies for high deposition welding. Unique Variable Polarity features are also available for welding aluminum.

Orbital Tube and Pipe Heads

Heads are designed for every application. Tube-to-tube and tube-to-sheet weld heads for the full range of tube diameters and specialized needs – high purity, narrow profile, low clearance profile, liquid and gas cooled, with/without removable cassette, and with small or large wire spools.

Welding Support Services (DTS)

Liburdi Dimetrics® provides a full range of customer and technical support services including field and factory service, in-house or on-site training programs, application consultation and engineering, and orbital tube and pipe rental equipment. Welding and maintenance technicians are also available for on-site, short or long term project support. Our in-house welding store provides same day shipment of welding accessories and consumables such as weld wire, electrodes, torch tips, gas cups, and LFXTM welding fluxes for complete customer support.
For further information on existing and future products, call us or visit our Website at www.liburdi.com

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